

The Wannier Function Approach to Photonic Crystal Circuits

Kurt Busch*

Institut für Theoretische Festkörperphysik, Universität Karlsruhe (TH),
76128 Karlsruhe, Germany

Over the past years, the fabrication of Photonic Crystals has matured to a point where the complex functional elements can be realized. This leads to serious challenges for the modeling of these systems and conventional electromagnetic solvers very quickly find themselves at the limits of their capabilities.

The Wannier function approach [1] provides a novel route to the efficient modeling of Photonic Crystals-based integrated optical circuits. Within this technique, the electromagnetic field is expanded into an orthogonal basis of Wannier functions which are derived from the Bloch functions of the underlying Photonic Crystal. This results in extremely small and sparse matrix problems and allows the efficient determination of cavity mode frequencies, waveguide dispersion relations, and transmission/reflection characteristics of multi-port functional elements [1, 2]. Together with efficient low-rank adjustment schemes and sensitivity analysis techniques [3], the Wannier function approach facilitates the design and optimization of devices with robust performance characteristics [2, 3, 4]. In particular, based on this Wannier function approach, a novel type integrated Photonic Crystal circuits based on the infiltration of low-index materials such as polymers or liquid crystals into selected void regions has been suggested [2]. This concept facilitates the design of a basic set of inherently tunable waveguiding structures for broad-band telecommunication applications [2, 4].

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